



National Aeronautics & Space Administration

2009 NASA PM Challenge



Let's Roll! Rolling Out the NASA Systems Engineering Framework

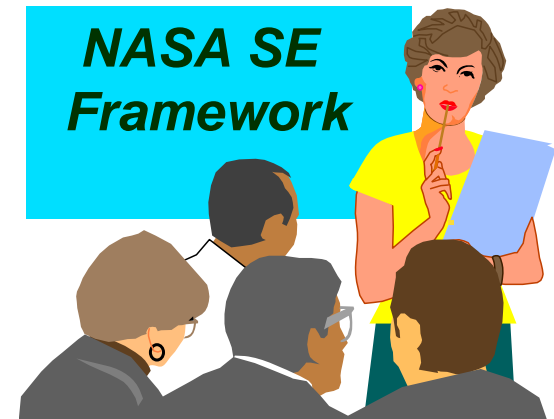
Wednesday, February 25, 2009
Hilton Ocean Front Hotel
Daytona Beach, FL

P. A. "Trisha" Jansma
NASA Systems Engineering Working Group (SEWG)
Jet Propulsion Laboratory
California Institute of Technology



Topics To Be Covered

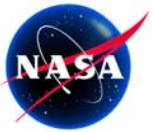
- NASA SE Excellence Initiative
- NASA SE Framework
- SE NPR Background and Rationale
- Overview of NASA SE NPR
- Implementation of the SE Framework
- Summary and Conclusions



Some of the work described in this presentation was performed at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration (NASA).

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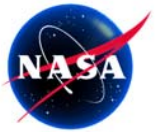


NASA SE Excellence Initiative

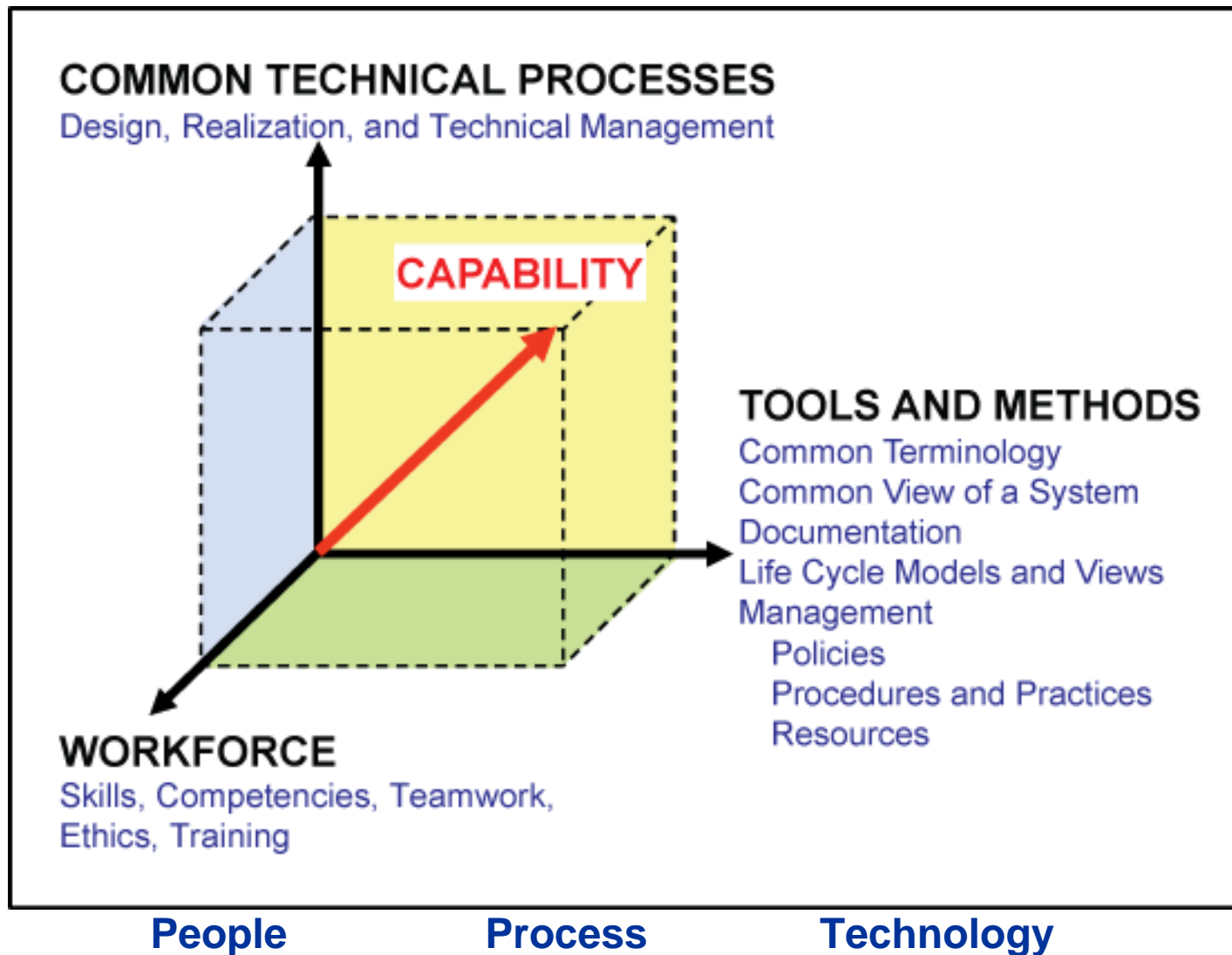
- Established in 2000 under the NASA Office of the Chief Engineer (OCE) to:

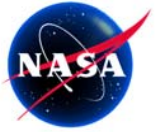


- Stimulate and enable the **development and advancement of a sound systems engineering capability** necessary for success in fulfilling the challenging and ambitious goals of the NASA Enterprises.
 - Address the need for **consistency in the basic approach to systems engineering** across the Agency, and for a **common systems engineering terminology**
- The NASA Systems Engineering Working Group (SEWG) was chartered to develop and document a common framework for systems engineering for use across the agency.
- The goals of the initiative are to:
 - Ensure **continuous improvement** of the NASA engineering **workforce** through relevant education, training and work experiences.
 - Ensure sound and **effective discipline and systems engineering**.
 - Develop and implement **advanced engineering infrastructure** to further enable the achievement of enterprise goals.
 - Provide value-added **cross-enterprise products and services** that enable the infusion of technology, knowledge, and capabilities to support innovation in engineering and push the state of the art.
 - Increase participation**, membership, and leadership in recognized **national and international engineering organizations**.

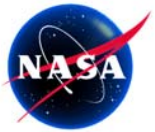


NASA SE Framework





Implementation and Deployment of the NASA SE Framework

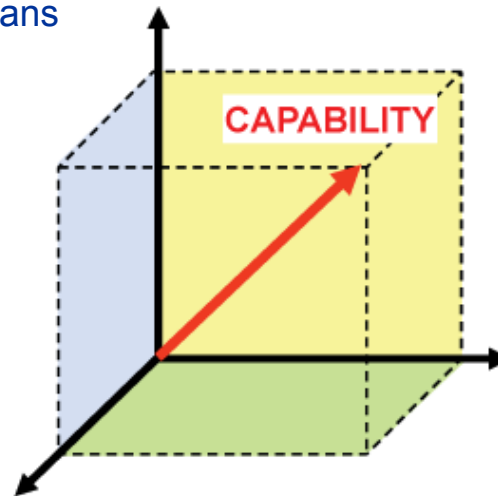


Deployment of the NASA SE Framework



Common Technical Processes

- SE NPR
- Center SE NPR Implementation Plans
- Center surveys (gap analysis against best practices in SE NPR Appendix C)
- Center Procedural Requirements

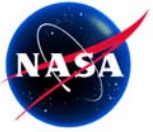


Tools and Methods

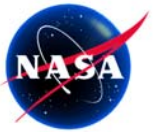
- NASA SE Handbook
- SE Community of Practice
- SE NPR in POLARIS
- Art and Science of SE
- SE Wiki
- SE Body of Knowledge
- SE Bibliography & References
- MBSE Initiative
- SE Tool Use Surveys
- Center SE-specific websites

Workforce, Knowledge and Skills

- SE Roadshow
- *Understanding NPR 7123.1A* course
- SE courses offered through NASA APPEL
- SE Behaviors Study
- SE Leadership Development Program (SELDP)
- Center SE OJT programs, SE Mentoring
- SE Seminars, NASA Masters Forum (SE Topics)
- SE Track at PM Challenge
- SE Activity of the Year Award
- SE Surveys
- Characterization of SE workforce, SE Community (target audience)



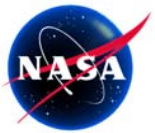
Common Technical Processes Axis of the NASA SE Framework



SE NPR Background and Rationale



- “Establishes a core set of common Agency-level technical processes and requirements needed to define, develop, realize, and integrate the quality of the system products created and acquired by or for NASA.”
- “Processes intended to clearly delineate a successful model to complete comprehensive technical work, reduce program and technical risk, and improve mission success.”
- Rationale: “. . .systems engineering at NASA requires the application of a systematic, disciplined engineering approach that is quantifiable, recursive, iterative, and repeatable for the development, operation, maintenance, and disposal of systems integrated into a whole throughout the life-cycle of a project or program.”



Contents of NASA SE NPR

Preface

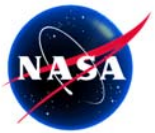
Chapters

1. Introduction
2. Institutional & Programmatic Requirements
3. Requirements for Common Technical Processes
4. NASA Oversight Activities on Contracted Projects
5. Systems Engineering Technical Reviews
6. Systems Engineering Management Plan

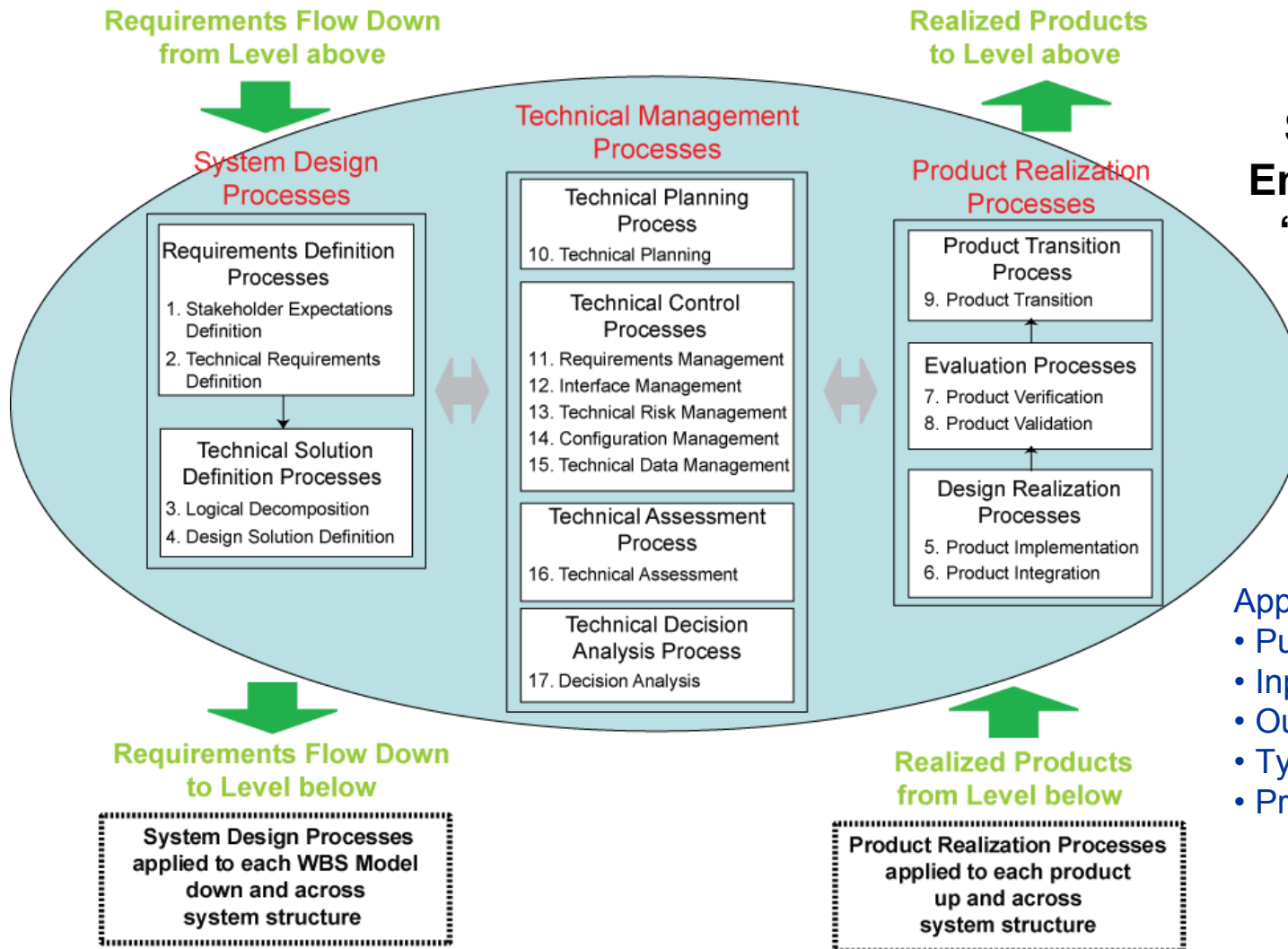
Appendices

- A. Definitions
- B. Acronyms
- C. Practices for Common Technical Processes
- D. Systems Engineering Management Plan
- E. Hierarchy of Related NASA Documents
- F. Tailoring
- G. Technical Review Entrance & Success Criteria
- H. Templates
- I. Additional Reading
- J. Index

57 requirements in 33 pages, 167 pages total

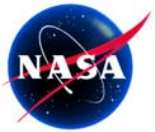


Common Technical Processes



**Systems Engineering
“Engine”**

- Appendix C contains:
- Purpose
 - Inputs & Sources
 - Outputs & Destinations
 - Typical Activities
 - Process Flow Diagram



Structure of SE Management Plan (SEMP)

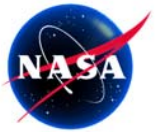


1. Purpose and Scope
2. Applicable Documents and Designated Governing Authority
3. Technical Summary
 - System Description
 - System Structure
 - Product Integration
 - Planning Context
 - Boundary of Technical Effort
 - Cross-References
4. Technical Effort Integration
5. Common Technical Processes Implementation
6. Technology Insertion
7. Additional SE Functions and Activities
 - System Safety
 - Engineering Methods & Tools
 - Specialty Engineering
8. Integration with the Project Plan Resource Allocation
9. Waivers
10. Appendices



The SEMP is a description of the technical work to be done.



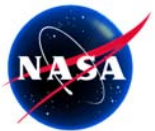


Technical Reviews

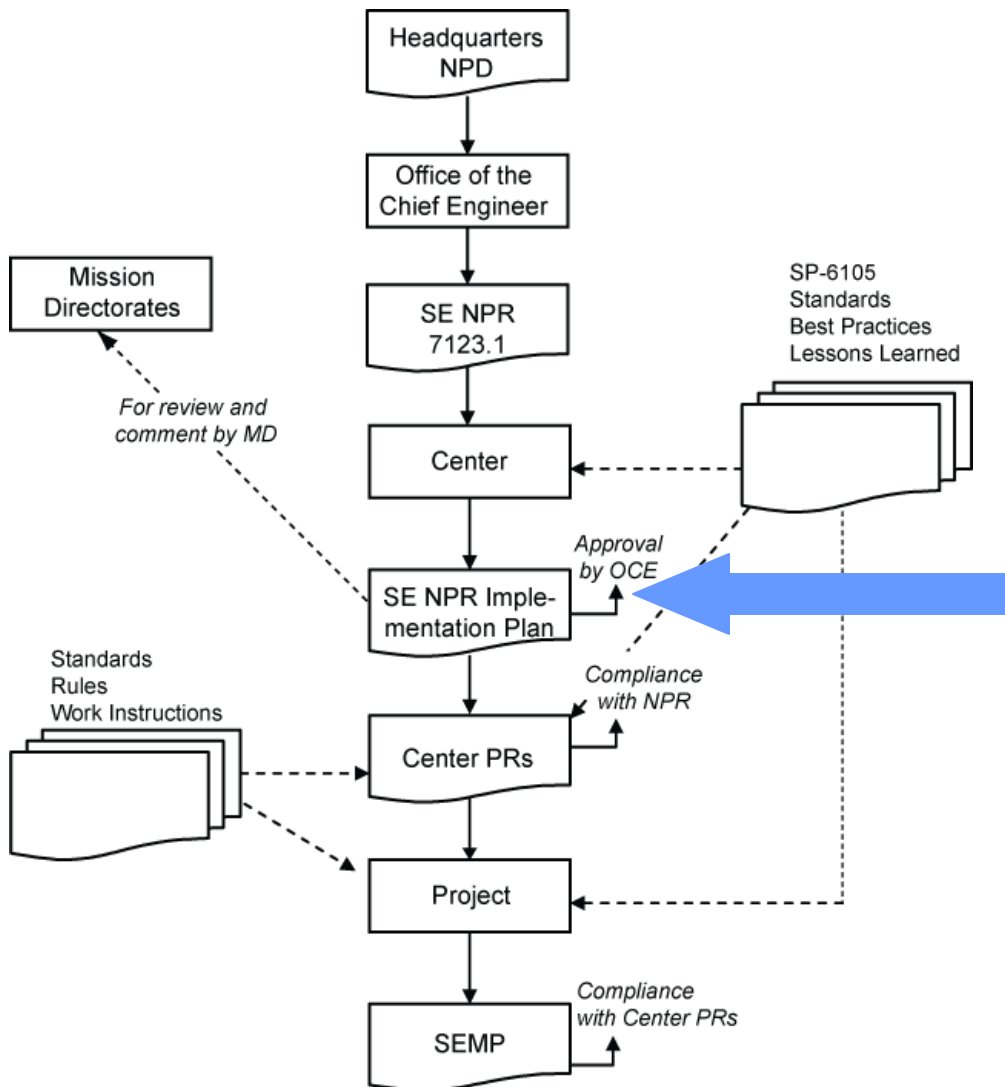
(with SE Contributions or led by SE)

- Program/System Requirements Review (P/SRR)
- Program/System Definition Review (P/SDR)
- Mission Concept Review (MCR)
- System Requirements Review (SRR)
- Mission Definition Review (MDR)
- System Definition Review (SDR)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Production Readiness Review (PRR)
- System Integration Review (SIR)
- Test Readiness Review (TRR)
- System Acceptance Review (SAR)
- Operational Readiness Review (ORR)
- Flight Readiness Review (FRR)
- Post Launch Assessment Review (PLAR)
- Critical Event Readiness Review (CERR)
- Post Flight Assessment Review (PFAR)
- Decommissioning Review (DR)
- Periodic Technical Review (PTR)
- Technical Peer Reviews

SE NPR specifies the review name, review purpose, life-cycle phase, entrance criteria and success criteria.



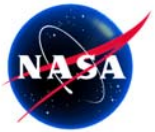
Implementation of the SE NPR



- Each NASA Center generates a **Center NPR Implementation Plan**.
- Compliance matrix within the plan lists each of the 57 requirements from the SE NPR
 - Shows which existing center documents and sections within them support compliance
 - Indicates whether compliance is full, partial or none
 - References any plans to close the gap.

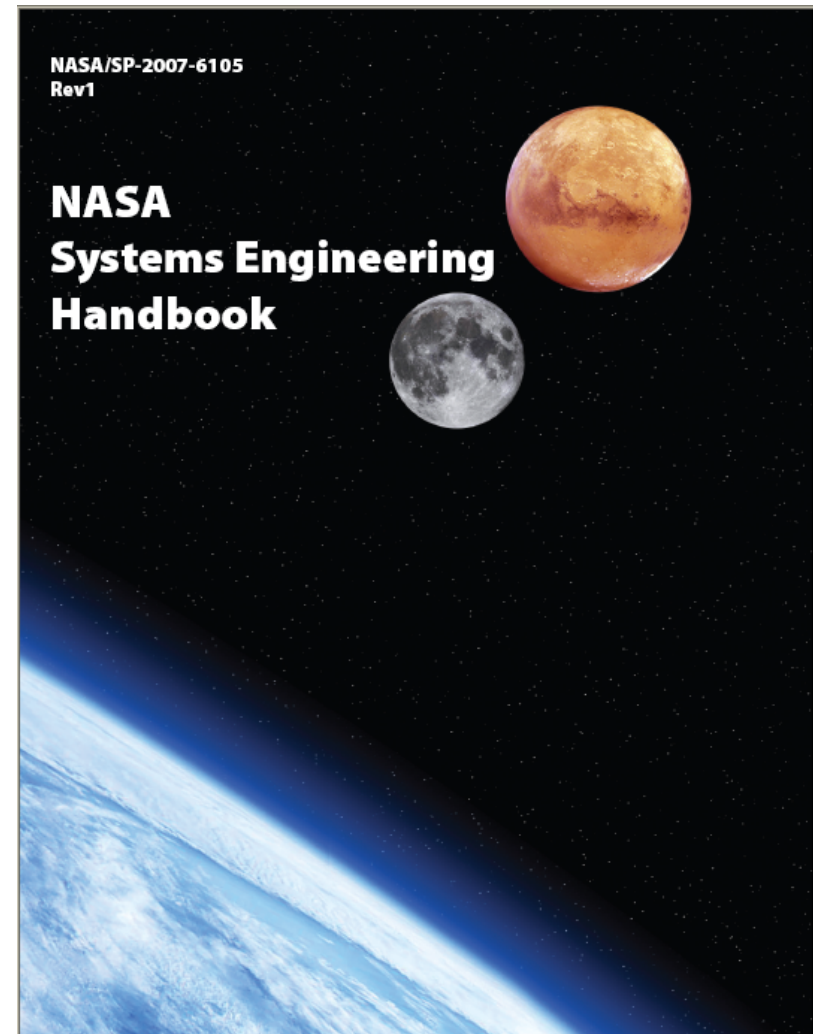


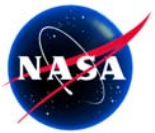
Tools and Methods Axis of the NASA SE Framework



NASA SE Handbook

- Includes general concepts and specific descriptions of processes, tools, and techniques.
- Provides information on systems engineering best practices and pitfalls to avoid.
- Makes the bridge from “typical” SE guidance back to the NASA Systems Engineering Process (NPR 7123.1)
 - Guidance from SE practitioners
 - Written by practitioners for practitioners
 - “How” vs. “What”
- Updates the guidance from SP-6105 (basic) 1995





2009 NASA PM Challenge SE Track

NEN SE Community of Practice



NEN SE CoP
is structured
along lines of
NASA SE
Framework

The screenshot displays the NASA Engineering Network (NEN) Systems Engineering Community of Practice (SE CoP) website. The page features a sidebar with navigation links, a main content area with a search bar and a 'Systems Engineering' section, and a 'NASA Systems Engineering Framework' diagram. The diagram is a 3D cube with axes labeled 'CAPABILITY', 'KNOWLEDGE', and 'SKILLS'. The 'KNOWLEDGE' axis is highlighted in yellow, and the 'SKILLS' axis is highlighted in green. The 'CAPABILITY' axis is highlighted in blue. The diagram is titled 'NASA Systems Engineering Framework'.

Common Technical Processes

- Systems Engineering NPR
- Center Systems Engineering NPR Implementation Plans
- Center surveys (gap analysis)
- Center Procedural Requirements

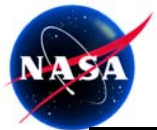
Tools and Methods

- Systems Engineering NPR in POLARIS
- NASA Systems Engineering Handbook
- Systems Engineering Body of Knowledge
- The Art and Science of Systems Engineering
- Systems Engineering Bibliography & References
 - Readings in Systems Engineering
- Systems Engineering Community of Practice
- Systems Engineering Wiki
- Model-Based Systems Engineering Initiative
- Center tool use surveys
- Center Systems Engineering-specific websites
 - GRC Engineering Systems Division
 - JPL Systems Engineering (JPL only)
 - JSC Systems Engineering Group
 - JSC System Management Office -- Systems Engineering

Workforce, Knowledge and Skills

- Systems Engineering Roadshow
- Understanding NPR 7123.1A course
- Systems Engineering courses offered through NASA APPEL
- Systems Engineering Workforce Development Strategy
- Systems Engineering Behaviors
- Systems Engineering Leadership Development Program (94 KB)
- Center Systems Engineering on the job training programs
- Systems Engineering Mentoring
- Systems Engineering Seminars
- Systems Engineering Track at NASA PM Challenge (2 MB)
 - PM Challenge 2009
- JSC Center Director's Systems Engineering Forum (250 KB)
 - Constellation Lunar Transportation Architecture Case Study by Brian Murhead (3.88 MB)
 - Managing Complex Projects by Wayne Hale (1.14 MB)
 - Managing Complex Projects (Transcript) by Wayne Hale (53 KB)
 - Lessons in Systems Engineering - The SSME Weight Growth History by Richard Ryan (3.78 MB)
 - JSC SE Forum: Recent SE Challenges at NavAir by Michael Gaydar (3.28 MB)
 - NASA JSC SE Panel: SE Challenges at NAVSEA by Brian Persons (6.62 MB)
 - Risk Informed Design of Altair by L. Dale Thomas (6 MB)
- Systems Engineering Activity of the Year Award
- Characterization of Systems Engineering workforce
- Systems Engineering Community (target audience)
- Systems Engineering Survey

<http://nen.nasa.gov/portal/site/llis/>



2009 NASA PM Challenge SE Track

NASA SE NPR in POLARIS



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

» POLARIS Home

Expand All | Collapse All

Useful Links

Programs & Projects @ NASA

Management Support

Systems Engineering Support

- Overview
 - FRAMEWORK
 - Implementation Architecture
 - Roles & Responsibilities
 - Oversight on Contracts
 - Common Technical Processes (SE Engine)
 - Technical Reviews
 - Requirements
 - Helpful Information
 - Requirements and Document Hierarchy
 - Roles and Responsibilities Requirements
 - Common Technical Process Requirements
 - Oversight on Contracted Project Requirements
 - Technical Review Requirements
 - SEMP Requirements
 - All Requirements
 - Requirements Search

Site Search: GO

» About POLARIS

- » Feedback
- » Sitemap
- » Acronyms
- » Definitions

Program/Project Online Library And Resource Information System
Resources for Program & Project Management

SYSTEMS ENGINEERING SUPPORT

Systems Engineering Framework

- The engineering of NASA systems requires the application of a systematic, disciplined engineering approach applied across the entire life cycle of a program or project.
- Systems engineering emphasizes safely achieving stakeholder requirements in the intended use environment over the system's planned life within cost and schedule constraints.
- The Systems Engineering Framework consists of three elements that together comprise an Agency-wide capability to perform successful SE in the engineering of NASA system products. NPR 7123.1 addresses the Common Technical Processes. The [SE Handbook](#) and other OCE initiatives address Tools, Methods, and Workforce. The relationship of the three elements is illustrated and described in the figure below.

Note: Click on each element title for a more detailed description.

COMMON TECHNICAL PROCESSES

Design, Realization, and Technical Management

TOOLS AND METHODS

- Common Terminology
- Common View of a System
- Documentation
- Life Cycle Models and Views
- Management Policies
- Procedures and Practices
- Resources

WORKFORCE

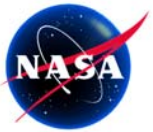
Skills, Competencies, Teamwork, Ethics, Training

Click [here](#) to print or download image

Source: NPR 7123.1A: 1.1.1.1, 1.2.1.1, 1.2.1.5, Figure 1-1

Last Updated: 02/21/2008

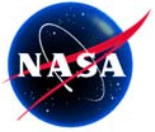
<https://polaris.nasa.gov/>



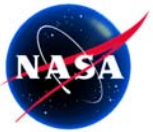
More SE Tools and Methods

- Systems Engineering Bibliography, References and Readings
 - Readings in Systems Engineering (NASA-SP-6102)
 - The Art and Science of Systems Engineering
- Systems Engineering Body of Knowledge (BOK) (future activity)
- Center Tool Use Surveys
- Model-Based Systems Engineering (MBSE) Initiative
- SE Wiki on NEN SE CoP
- Center SE-specific Websites





Workforce, Knowledge and Skills Axis of the NASA SE Framework



NASA SE NPR Course

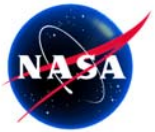
- Two-day course on the NASA Systems Engineering Processes and Requirements, NPR 7123.1A
- Course is currently under development and will be offered later in 2009.



Where the rubber meets the road!

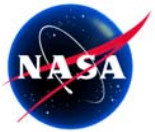
Potential Topics To Be Covered

- Background and Policy Related to SE NPR 7123.1A
- NPR 7123.1A Overview
- Systems Engineering Application Context
- Common Technical Processes
 - Part I - System Design Processes
 - Part II - Product Realization Processes
 - Part III - Technical Management Processes
- Conclusions



SE Related Training Courses

- Existing APPEL courses:
 - System Requirements Definition & Management
 - Introduction to Systems Engineering at NASA
 - Foundations of Aerospace at NASA
 - Project Management and Systems Engineering course
 - Advanced Project Management and Systems Engineering course
 - Fundamentals of Systems Engineering
 - Concept Exploration & System Architecting
 - Developing & Implementing a Systems Engineering Mgmt. Plan
 - Space System Verification and Validation
 - Decision Analysis
- Courses To Be Developed and/or Leveraged :
 - Overview of SE NPR
 - Management of Space Technology Programs
 - Configuration Management
 - Design for Manufacturability and Assembly
 - Center-specific SE courses
 - Defense Acquisition University (DAU) SE Training courses

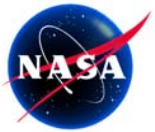


NASA SE Behavior Study

- Interviewed and shadowed 38 highly regarded systems engineers from across the Agency
- Compiled and analyzed results by Center and across the Agency
- Generated NASA Systems Engineering Behavior Study report Oct. 2008
- Identified potential uses of these results:
 - To provide a more balanced picture of systems engineering
 - To train, coach, mentor and develop NASA's current and future systems engineers
- Identified three levels of behaviors:
 - top level behavioral themes
 - middle competencies
 - low level observable behaviors
- Top themes included:
 - Leadership
 - Attitudes and Attributes
 - Communication
 - Problem Solving & Systems Thinking
 - Technical Acumen



See presentation by Christine Williams and Mary Ellen Derro on this topic later today in PMC SE Track I.



NASA SE Leadership Dev. Program

SELDP Selection Criteria

- Target: Individuals Transitioning to Multi-Disciplinary System Engineering Activity
 - Expect GS 13-14, Some GS-15
- Engineering Bachelors Degree or AST Equivalent
- Science of SE: Experience, Developmental Preparation, Center Endorsement, & Maturity/Judgment
- Art of SE: Leadership Skills, Attitudes, Attributes, Communication Ability, Problem Solving & Systems Thinking

15-20 candidates
selected across the
Agency each year.



SELDP Program Elements

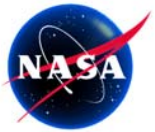
- Developmental Assignments: Hands-On at Centers
- Technical Training: Gap Analysis Against SE DACUM & IDP Needs
- Assessment Instruments: Leadership Self Awareness
- Leadership Development: Models & Experiential Learning
- Leadership Training: Leadership Courses/Team Building
- Leadership Coaching: Personalized Development
- Benchmarking: With Leading SE Organizations
- Center Visits: Greater Understanding Across Agency
- Mentoring: Home & Assignment
- Job Shadowing: Top SE Leaders



NASA Forums on SE Topics

- NASA OCE plans to hold a series of SE Forums at various centers with agency-wide SE participation, either in person or via WebEx.
- The first SE Forum, a four-hour panel held at JSC on Aug. 21, 2008, featured distinguished experts in SE design who shared their insights and lessons learned from challenges similar to those facing the Constellation Program today.
 - The panel presentations were followed by a question and answer session.
 - The panel was facilitated by Steve Kapurch from NASA OCE.

Panel Members	Affiliation and Role	Presentation Topic
Wayne Hale	NASA Deputy Associate Administrator for Strategic Partnerships	Managing Complex Projects
Richard Ryan	Technical Specialist, Chief Engineer's Office, Marshall Space Flight Center	Lessons in Systems Engineering – The SSME Weight Growth History
Brian Muirhead	Program Systems Engineer (PSE), Constellation Program	Constellation Lunar Transportation Architecture Case Study
L. Dale Thomas	Deputy Program Manager, Constellation Program	Risk Informed Design of Altair
Brian Persons	Engineering Director, Naval Sea Systems Command	SE Challenges at NAVSEA
Michael Gaydar	Chief Systems Engineer, Naval Air Systems Command	Recent SE Challenges at NavAir

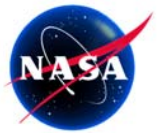


NASA SE Activity of the Year Award



(initial concept under consideration)

- **Purpose of SEOY:** to recognize excellence in the application of SE practices which results in the development of highly successful products or services.
 - Similar in concept to the NASA Software of the Year Award
- The award will be presented to “a distinguished individual or team, who by their achievements in systems engineering have clearly demonstrated unique benefits to major outcomes enhancing or meeting NASA’s needs.”
- The primary selection criteria will be the demonstration of significant verifiable contributions utilizing the art and science of Systems Engineering best practices resulting in program success.
- Initial award will be given at 2010 NASA PM Challenge.



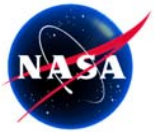
NASA SE Seminar Series

(under consideration)



- Quarterly or bi-monthly seminar series across the agency to highlight some aspect of SE (via ViTS or WebEx?)
- Possible topics include:
 - Art and Science of SE
 - Gentry Lee video on SE Behaviors and/or NASA SE Behaviors Study results
 - SE and recent results on a current planetary mission, e.g., Phoenix
 - SE and recent results on a current earth science mission
 - SE and recent results on a current astronomy mission
 - SE and recent results from the ISS
 - SE and recent results in aeronautics
 - Model-based Systems Engineering (MBSE)
 - SE Indicators
 - Technologies and tools that support SE
 - SE in Formulation
 - SE in Operations
 - Selected topics and examples from the SE Handbook
 - Panel of grads from SELDP and other SE programs on what they learned (upon graduation, of course)





2009 NASA PM Challenge SE Track

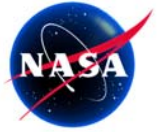
SE Activities at NASA PM Challenge 2009



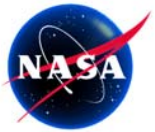
- Date: February 24-25, 2009
- Keynote Speaker: Chris Scolese
 - “Why We Do What We Do”
- SE Panel on Art & Science of SE
 - Panel Chair: Marton Forkosh
- Two SE Tracks with ~18 sessions
 - SE Track Chair: Steve Kapurch
 - Topics range from SE Leading Indicators and MBSE to lessons learned and the results of the NASA SE Behavior Study.



<http://pmchallenge.gsfc.nasa.gov/>



Summary and Conclusions

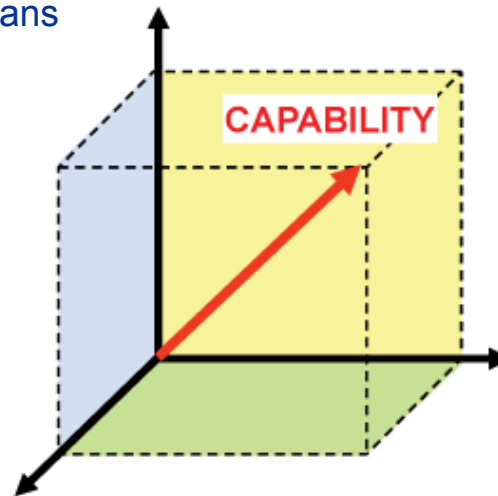


Deployment of the NASA SE Framework



Common Technical Processes

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- Center Procedural Requirements

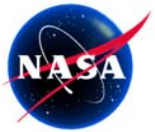


Tools and Methods

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- SE Community of Practice
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- SE Wiki
- SE Body of Knowledge
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- SE Tool Use Surveys
- Center SE-specific websites

Workforce, Knowledge and Skills

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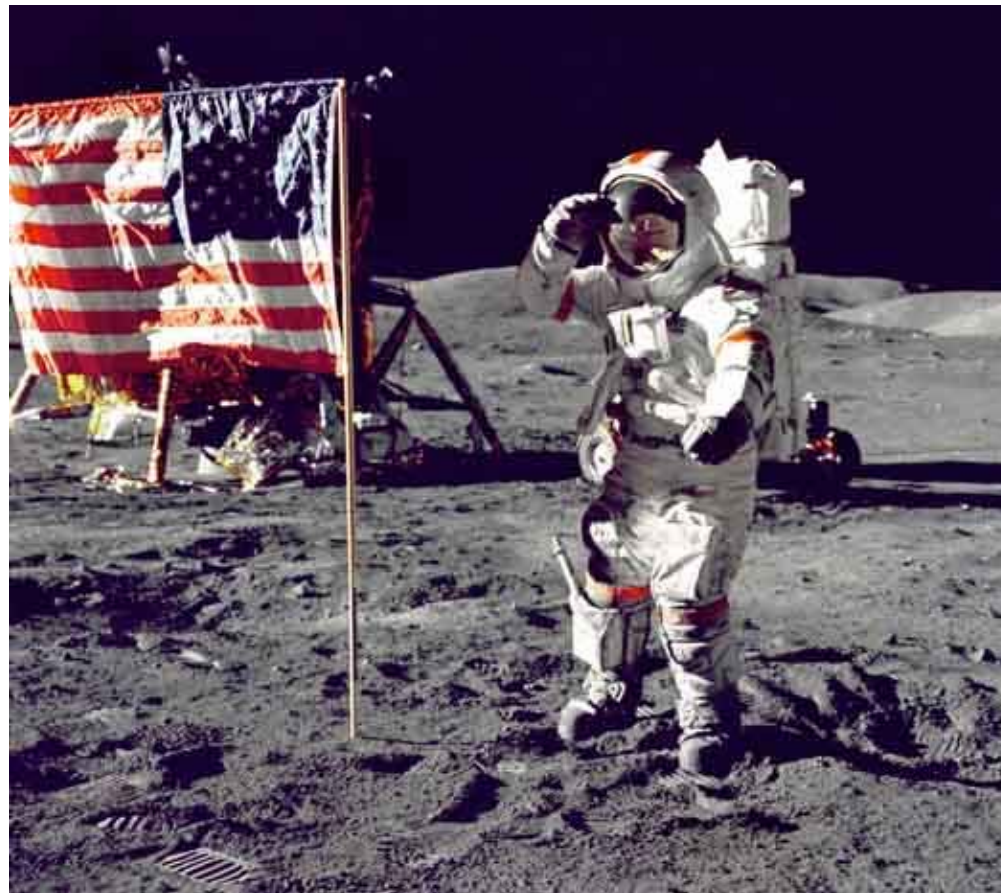


Balancing the Art and Science of SE

*It takes both of these ingredients
to make NASA a success.*

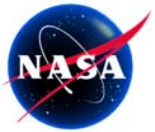
Art
of SE

Technical
Leadership



Science
of SE

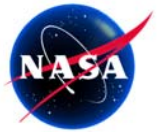
Systems
Management



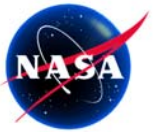
Summary and Conclusions

- Systems Engineering is a critical core competency for successful NASA missions.
 - We must balance both the art and science of SE.
- All three axes of the NASA SE Framework are in the process of being deployed:
 - Common Technical Processes
 - Tools and Methods
 - Workforce, Knowledge and Skills
- Much has been accomplished to date and more is still to come.
- The deployment of the NASA SE Framework will have a profoundly positive impact on:
 - how systems engineering is practiced across the Agency
 - the efficiency and effectiveness of future missions.



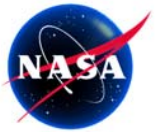


Backup Slides



SEF Deployment Lessons Learned

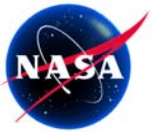
1. Build on previous efforts.
2. Address all three aspects of change: people, process and technology.
3. Identify and prioritize the target audience.
4. Start by defining the basic systems engineering processes.
5. Utilize many reviewers to promote ownership.
6. Allocate sufficient time for curriculum development
7. Evaluate and select tools to support the design process.
8. Use organizational change management (OCM) and customer relationship management (CRM) to facilitate change.
9. Address factors that engender resistance to change.
10. Communicate via multiple avenues and promote shamelessly.



Institutional & Programmatic Requirements



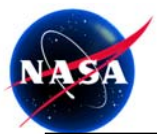
- Roles and responsibilities for implementing and ensuring compliance with the NPR.
 - **Office of the Chief Engineer (OCE)** ensures compliance with the SE NPR.
 - **Center Directors** (or their designees) develop the SE NPR Implementation Plan, establish policies, procedures and processes, and perform an SE NPR Center Survey.
 - **Designated Governing Authority (DGA)** for the technical effort in the SE NPR is the Center Director or the person or organization that has been designated by them.
 - DGA is typically the final approval signature on the Systems Engineering Management Plans, waiver authorizations, and other key technical documents.
 - DGA has the final approval signature to ensure independent assessment of technical content and waiver authorizations that pertain to the SE NPR.
 - **Technical teams** execute the Center processes that implement the SE NPR.



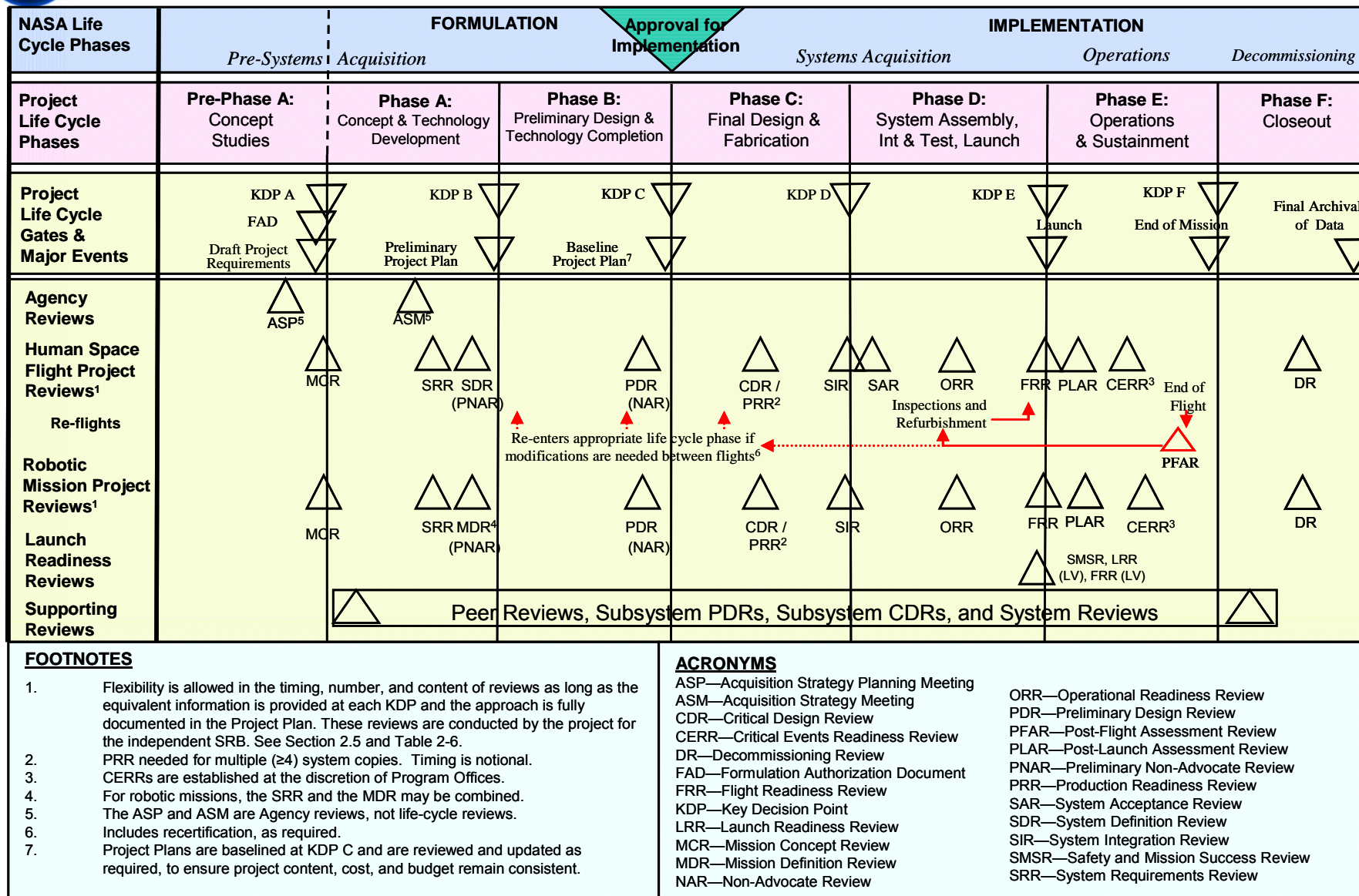
Oversight of Contracted Projects

- The SE NPR defines a minimum set of technical activities and requirements for a NASA project technical team to perform on projects where prime or external contractors do the majority of the development effort.
 - *prior to contract award*
 - **technical work products** to be delivered by the contractor, including
 - a contractor SEMP that specifies their systems engineering approach for requirements development; technical solution definition; design realization; product evaluation; product transition; and technical planning, control, assessment, and decision analysis.
 - *during contract performance*
 - **technical oversight** activities established in the NASA SEMP
 - under the authority of the Cognizant Contracting Officer (CCO)
 - *upon completion of the contract*
 - **scheduled milestone reviews** to finalize Government acceptance of the deliverables
 - **product transition** to the customer and/or disposal as defined in the NASA SEMP





NASA Project Life-Cycle



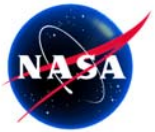
FOOTNOTES

- Flexibility is allowed in the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan. These reviews are conducted by the project for the independent SRB. See Section 2.5 and Table 2-6.
- PRR needed for multiple (≥4) system copies. Timing is notional.
- CERRs are established at the discretion of Program Offices.
- For robotic missions, the SRR and the MDR may be combined.
- The ASP and ASM are Agency reviews, not life-cycle reviews.
- Includes recertification, as required.
- Project Plans are baselined at KDP C and are reviewed and updated as required, to ensure project content, cost, and budget remain consistent.

ACRONYMS

ASP—Acquisition Strategy Planning Meeting
 ASM—Acquisition Strategy Meeting
 CDR—Critical Design Review
 CERR—Critical Events Readiness Review
 DR—Decommissioning Review
 FAD—Formulation Authorization Document
 FRR—Flight Readiness Review
 KDP—Key Decision Point
 LRR—Launch Readiness Review
 MCR—Mission Concept Review
 MDR—Mission Definition Review
 NAR—Non-Advocate Review

ORR—Operational Readiness Review
 PDR—Preliminary Design Review
 PFAR—Post-Flight Assessment Review
 PLAR—Post-Launch Assessment Review
 PNAR—Preliminary Non-Advocate Review
 PRR—Production Readiness Review
 SAR—System Acceptance Review
 SDR—System Definition Review
 SIR—System Integration Review
 SMSR—Safety and Mission Success Review
 SRR—System Requirements Review



Common Technical Processes – System Design Processes



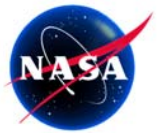
Process Category	Process Name	Process Purpose	Process Use
Requirements Definition Processes	1. Stakeholder Expectation Definition	Definition of stakeholder expectations for the applicable WBS model.	To elicit and define use cases, scenarios, operational concepts, and stakeholder expectations for the applicable product-line life-cycle phases and WBS model.
	2. Technical Requirements Definition	Definition of the technical requirements from the set of agreed upon stakeholder expectations for the applicable WBS model	To transform the baselined stakeholder expectations into unique, quantitative, and measurable technical requirements expressed as “shall” statements.
Technical Solution Definition Processes	3. Logical Decomposition	Logical decomposition of the validated technical requirements of the applicable WBS model.	To improve understanding of the defined technical requirements and the relationships among the requirements and to transform the defined set of technical requirements into a set of logical decomposition models.
	4. Design Solution Definition	Designing product solution definitions within the applicable WBS model that satisfy the derived technical requirements	To translate the outputs of the logical decomposition process into a design solution definition that is in a form consistent with the product-line life-cycle phase and WBS model.



Common Technical Processes – Product Realization Processes

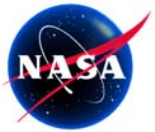


Process Category	Process Name	Process Purpose	Process Use
Design Realization Processes	5. Product Implementation	Implementation of a design solution definition by making, buying, or reusing an end product of the applicable WBS model	To generate a specified product of a WBS model through buying, making, or reusing in a form consistent with the product-line life-cycle phase exit criteria and that satisfies the design solution definition specified requirements.
	6. Product Integration	Integration of lower level products into an end product of the applicable WBS model in accordance with its design solution definition.	To transform the design solution definition into the desired end product of the WBS model through assembly and integration of lower level, validated end products.
Evaluation Processes	7. Product Verification	Verification of end products generated by the product implementation process or product integration process against their design solution definitions.	To demonstrate that an end product generated from product implementation or product integration conforms to its design solution definition requirements as a function of the product-line life-cycle phase.
	8. Product Validation	Validation of end products generated by the product implementation process or product integration process against their stakeholder expectations.	To confirm that a verified end product generated by product implementation or product integration fulfills (satisfies) its intended use when placed in its intended environment and to ensure that any anomalies discovered during validation are appropriately resolved prior to delivery of the product.
Product Transition Process	9. Product Transition	Transitioning end products to the next higher level WBS-model customer or user.	To transition a verified and validated end product that has been generated by product implementation or product integration to the customer at the next level in the system structure.



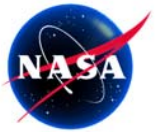
Common Technical Processes – Technical Management Processes

Process Category	Process Name	Process Purpose	Process Use
Technical Planning Process	10. Technical Planning	Planning the technical effort	To plan for the application and management of each common technical process and to identify, define, and plan the technical effort applicable to the product-line life-cycle phase for WBS model.
Technical Assessment Process	16. Technical Assessment	Making assessments of the progress of planned technical effort and progress toward requirements satisfaction	To help monitor progress of the technical effort and provide status information for support of the system design, product realization, and technical management processes.
Technical Decision Analysis Process	17. Decision Analysis	Making technical decisions	To help evaluate technical decision issues, technical alternatives, and their uncertainties to support decision making.



Common Technical Processes – Technical Management Processes (Cont.)

Process Category	Process Name	Process Purpose	Process Use
Technical Control Processes	11. Requirements Management	Management of requirements defined and baselined during the application of the system design processes	To (a) manage the product requirements identified, baselined, and used in the definition of the WBS model products during system design; (b) provide bidirectional traceability back to the top WBS model requirements; and (c) manage the changes to established requirement baselines over the life-cycle of the system products.
	12. Interface Management	Management of the interfaces defined and generated during the application of the system design processes	To (a) establish and use formal interface management to assist in controlling system product development efforts when the efforts are divided between Government programs, contractors, and/or geographically diverse technical teams within the same program or project and (b) maintain interface definition and compliance among the end products and enabling products that compose the system, as well as with other systems with which the end products and enabling products must interoperate.
	13. Technical Risk Management	Management of the technical risk identified during the technical effort.	To examine on a continuing basis the risks of technical deviations from the project plan and identify potential technical problems before they occur so that risk-handling activities can be planned and invoked as needed.
	14. Configuration Management	Configuration management for end products, enabling products, and other work products placed under configuration control	To (a) identify the configuration of the product or work product at various points in time; (b) systematically control changes to the configuration of the product or work product; (c) maintain the integrity and traceability of the configuration of the product or work product throughout its life; and (d) preserve the records of the product or end product configuration throughout its life-cycle.
	15. Technical Data Management	Management of the technical data generated and used in the technical effort.	To (a) provide the basis for identifying and controlling data requirements; (b) responsively and economically acquire, access, and distribute data needed to develop, manage, operate, and support system products over their product-line life; (c) manage and disposition data as records; (d) analyze data use; (e) if any of the technical effort is performed by an external contractor, obtain technical data feedback for managing the contracted technical effort; and (f) assess the collection of appropriate technical data and information.



SEMP Content



1. It's a plan for doing the project technical effort by a technical team for a given WBS Model in the system structure and to help meet life cycle phase exit criteria

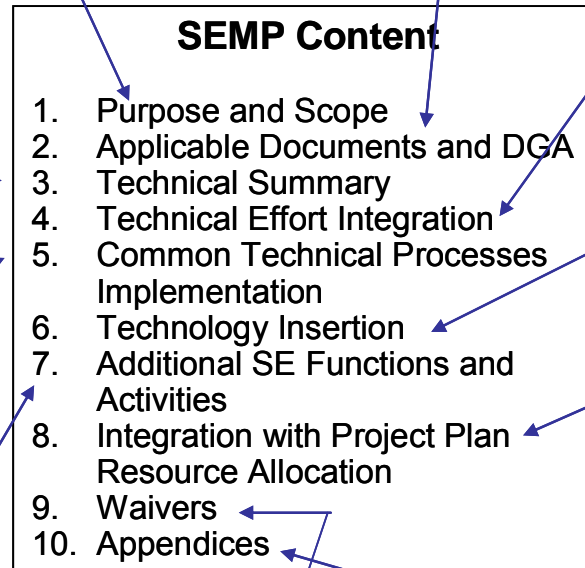
2. Describes major standards and procedures the technical effort needs to follow



3. Describes the problem to be solved and the purpose, context and products of the WBS Model to be developed and integrated with other interfacing systems identified



5. Describes how each process activity and task will be accomplished, directed and managed including cost estimates, schedule, people, resources and use of methods and tools



4. Explains how the inputs and technical efforts will be integrated

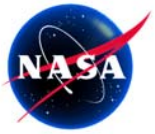
6. Identifies incorporation plan for key technologies and their risks and insertion criteria

8. Explains how the technical effort will be integrated with project management

7. Other essential considerations such as system safety, engineering specialties, methods and tools,

9. Identifies approved waivers and tailoring of NPR

10. Separate information needed for SEMP use and maintenance; summary of other technical plans



Center NPR Implementation Plan Outline

1. Introduction

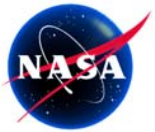
- Purpose
- Scope
- Background
- Designated Governing Authority

2. Reference Documents

3. Compliance With the SE NPR

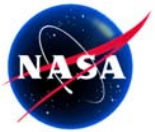
- Description of Center Compliance Methodology
- Compliance Matrix
- Plan to Close Gaps

4. Other

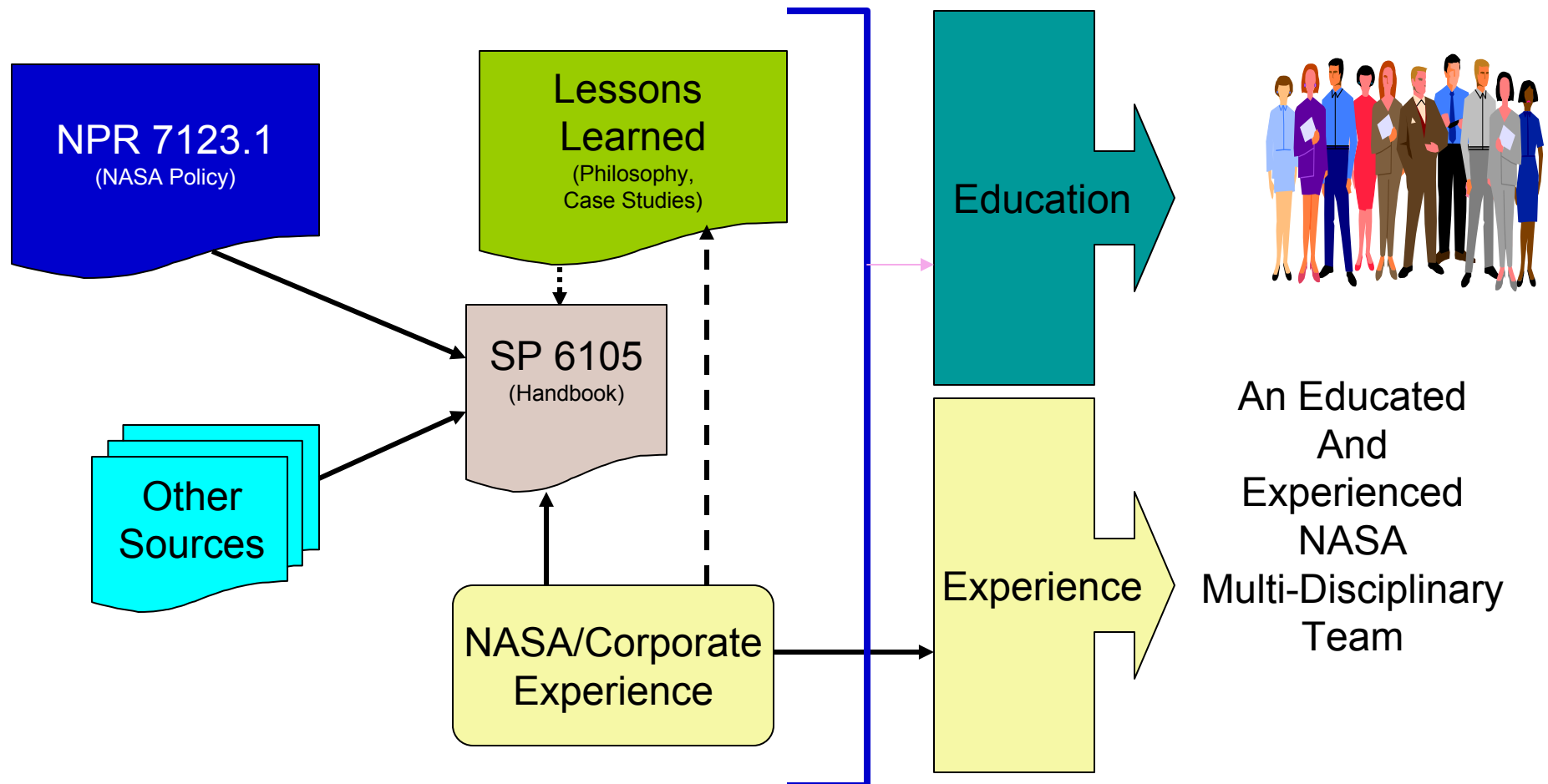


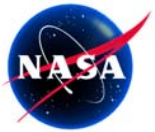
NASA SE Target Audience

Segment Name	Segment Description
NASA Senior Managers	NASA Office of the Chief Engineer, Center Chief Engineers, NASA Engineering Management Board, NASA Sponsors and Program Managers
Other Mission Support Office Personnel	NASA Office of Human Capital and Center HR Directorates, Acquisition personnel, Contracts Offices, Legal, Cost, etc.
Technical Community	Scientists, Technical Personnel, and Engineers in specific disciplines, e.g., avionics, mechanical, propulsion, thermal, etc.
Missions and Projects	Project Managers and Program Executives
SE Managers	Branch Heads of systems engineering intensive branches
Systems Engineers	Systems Engineers (both lead and support) of subsystems, projects or programs



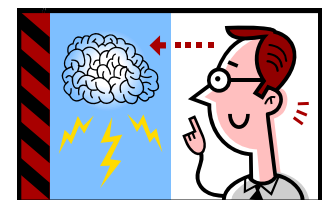
Essential Elements of SE at NASA

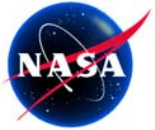




The Art and the Science of SE

- **Art of SE – Technical Leadership**
 - Balances broad technical domain knowledge, engineering instinct, problem solving, creativity, leadership and communication to develop new missions and systems.
 - Focuses on a system's technical design and technical integrity throughout its life-cycle
- **Science of SE – Systems Management**
 - Involves rigorously and efficiently managing the development and operation of complex systems
 - Emphasis is on organizational skills, processes and persistence.
- To succeed, we must blend technical leadership and systems management into complete systems engineering.
 - Anything less results in systems not worth having or that fail to function or perform.





Personal Characteristics of Good SEs

